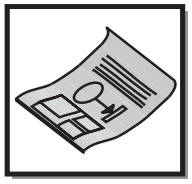
Improve Indoor Air Quality
An Overview

Builder Guide
(in conjunction with the EPA Indoor Environments Division)



DESCRIPTION

In the last several years, a growing body of scientific evidence has indicated that the pollutant levels within homes can be higher than in outdoor air, even in large, industrialized cities. People spend approximately 90 percent of their time indoors. The potential health effects from indoor air pollution vary greatly and range from allergies and asthma to cancer and even death.

Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems in homes. Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the home. High temperature and humidity levels can also increase concentrations of some pollutants.

There are many potential sources of indoor air pollution. These include:

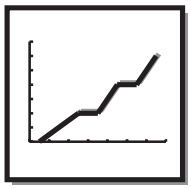
- combustion sources such as oil, gas, kerosene, coal, wood, and tobacco products;
- building materials and furnishings such as insulation, carpet, and cabinetry or furniture made of certain pressed wood products;
- products for household cleaning and maintenance, personal care, or hobbies;
- central heating and cooling systems and humidification devices; and
- outdoor sources such as radon, pesticides, and outdoor air pollution.

The importance of any source depends on how much of a given pollutant it emits and how hazardous those emissions are, as well as the sensitivity of the population.

One component of maintaining good indoor air quality is the elimination, reduction, or management of the pollutant sources. Another important component is effective ventilation.

If too little outdoor air enters a home, pollutants can accumulate to levels that can pose health and comfort problems. In the past, homes had a significant amount of “natural” ventilation from leaks in the building. However, because some weather conditions can drastically reduce the amount of outdoor air that enters a home, pollutants can build up even in homes that are normally considered "leaky." Moreover, uncontrolled leaks can introduce moisture and humidity, pollens, and dust inside framing systems and interior spaces. This can lead to future air quality and durability problems. Beyond indoor air quality problems, leaky homes can be very expensive to heat and cool and difficult to maintain comfort.

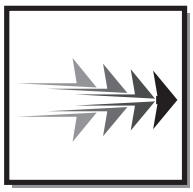
Building leaky homes isn’t the answer. Tight energy-efficient homes save energy and money. With proper mechanical ventilation, they can also have better indoor air quality than a leaky home. The reason is control. In a leaky home, outdoor air enters the house—through cracks, unsealed joints, and penetrations, for example—intermittently, depending largely on the weather. Some times there will be too much leakage, resulting in a drafty house. Other times there won’t be enough, resulting in a stuffy house. Mechanical ventilation in a well-insulated, well-sealed house, however, can exhaust pollutants and bring in outdoor air in a planned way. This makes a house both comfortable and energy- efficient.



BENEFITS

- Look for comfortable, healthy homes to result in a more desirable home and increase customer satisfaction. This can close sales and increase referrals.

- Construction practices that promote good indoor air quality also help protect the house itself. For example, controlling moisture will reduce mildew odors, premature paint failure, rot, and structural damage, and thus reduce callbacks.



INTEGRATION

Several construction practices, expanded upon in the fact sheets that follow, help to ensure good indoor air quality:

- **Energy-Efficient Construction.**

Building tight, well-insulated homes reduces heating and cooling costs. When combined with mechanical ventilation and pollutant source control, tight, energy- efficient homes are comfortable, economical, and promote good health. Indoor air quality and energy efficiency go hand-in-hand.

- **Moisture Control Techniques.**

Controlling moisture in a home can help reduce mold, mildew, and other biological growth that are linked to a variety of health effects. Methods to control moisture include building an energy-efficient home with proper air sealing, proper use of vapor barriers, and vapor diffusion strategies. The entire building envelope, from the foundation to the roof, should be designed not only to prevent moisture entry, but also to allow any moisture which does enter a means of escape. Proper ventilation can help ensure that indoor humidity levels remain at acceptable levels.

- **Pollutant Source Control.**

Eliminating or controlling individual sources of pollution are important steps in providing good indoor air quality. By using appropriate materials, isolating materials that may cause problems, and providing adequate ventilation, the levels of pollutants indoors can be greatly reduced.

- **Mechanical Ventilation.**

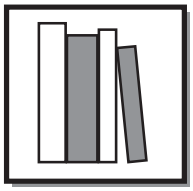
Proper ventilation removes or dilutes stale air from your home, and provides cleaner air from outdoors. There are many approaches to ventilation that achieve these goals. So, “build it tight, and ventilate right.”

- **Wise Use of Combustion Equipment.**

The selection, installation, and integration of combustion equipment with other systems is an important part of building a home with healthy indoor air. Combustion appliances are usually safe. However, under certain conditions, these appliances can produce combustion pollutants that can damage your health, or even kill you. In addition, improperly vented appliances can add large amounts of moisture to the air, potentially resulting in both biological growth and damage to the house. Fortunately, builders can take steps to reduce the risks for combustion equipment.

- **Operate and Maintain Home Properly.**

How a house is operated, maintained, and lived in is one of the most important factors affecting indoor air quality. Planning for this maintenance during the construction process and educating the home owner will not only promote good indoor air quality, but will also decrease problems with the physical structure of the house over time.



RESOURCES

- *Builder’s Guide - Mixed Climate; Builder’s Guide - Cold Climate; Builder’s Guide - Hot-Dry & Mixed Dry Climates.* By Joseph Lstiburek. Energy Efficient Building Association & Building Science Corporation. 1998.
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- *The Inside Story*. U.S. EPA 402-K-93-007. April 1995.
- *Understand Ventilation*. By John Bower. The Healthy House Institute. 1995.
- *No Regrets Remodeling*. Home Energy Magazine. 1997.
- *Building Air Quality: A Guide for Building Owners and Facility Managers*. U.S. EPA & National Institute for Occupational Safety and Health (NIOSH). EPA-400-1-91-033. December 1991.
- The Residential Energy Efficiency Database www.its-canada.com/reed/index.htm

Improve Indoor Air Quality

Ventilation

Fact Sheets
Please refer to pages 2D1 through 2D3 of this Builder Guide

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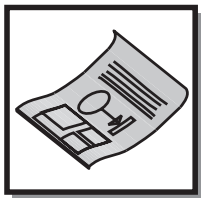
Improve Indoor Air Quality with Moisture Control

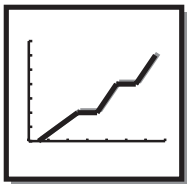
Builder Guide
(in conjunction with the EPA Indoor Environments Division)



DESCRIPTION

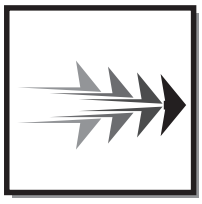
Too much moisture in a home can lead to mold, mildew, and other biological growth. This in turn can lead to a variety of health effects ranging from allergic reactions to asthma attacks and hypersensitivity pneumonitis. Excess moisture can take the form of high relative humidity; infiltration of outdoor or exfiltration of indoor air through the building shell, including the foundation; plumbing leaks; or other sources. High relative humidity or water that enters building cavities and is not allowed to dry quickly can lead to problems such as rot, structural damage, and premature paint failure.

Methods to control moisture include building an energy-efficient home with proper air sealing, proper use of vapor barriers, and vapor diffusion strategies. The entire building envelope, from the foundation to the roof, should be designed not only to prevent moisture entry, but also to allow any moisture that does enter a means to escape. People and their activities in a home are big sources of moisture; thus proper ventilation also is important in order to maintain indoor humidity levels within an acceptable range.



BENEFITS

- Controlling moisture will reduce mildew odors, premature paint failure, rot, and structural damage, which will reduce callbacks and decrease liability exposure.
- Comfortable, healthy homes can increase customer satisfaction by providing a more desirable home. This can close sales and increase referrals.



INTEGRATION

- **Drain Near Foundation.**

Keeping rainwater away from the foundation wall perimeter and draining groundwater from around the footing are essential to managing water. Foundation walls should be designed to prevent capillary action from drawing moisture into the home. This requires either dampproofing with a coating or membrane, or the use of certain rigid insulation which provides both a drainage plane and capillary break and allows the foundation to dry to the outside.

- **Proper Outdoor Drainage.**

Regrade the ground to drain surface water away from the house. Route downspouts and other drainage so they discharge away from the foundation.

- **Concrete Slabs.**

The slab (or floor) must also be kept dry and allowed to dry if it becomes wet. An important feature of a moisture-resistant slab is a capillary break, such as a layer of coarse gravel, under the slab. This layer is also an important part of a soil-gas reduction system (see “Soil-Gas Reduction System” fact sheet for more information). Designs can also include the use of polyethylene sheeting and/or sub-slab insulation to warm the slab and promote drying. Consult the resources listed in this fact sheet for specific designs.

- **Crawl Spaces.**

As with other foundation types, crawl spaces should be constructed to manage water, including both groundwater and water vapor. Traditional ventilation may prove inadequate if water is not managed. There are two designs that should be considered. First is building the crawlspace as a “short basement,” complete with perimeter insulation and air sealing, and treating the space like other conditioned space in the home. This approach is allowed in some code jurisdictions if the

crawl space is called a short basement and meets normal requirements for basement construction.

The other approach is insulating the floor area, taking care to seal duct work and insulate plumbing that passes through the floor or into the crawl space, and providing as much ventilation as possible under the crawl space.

In either case, a polyethylene barrier should be used over the soil to control moisture. Some builders are installing soil-gas reduction systems (See "Soil-Gas Reduction System" fact sheet) to control crawl space moisture in homes.

- **Bulk Water Management.**

Use proper flashing and drainage details to keep rain and other water from entering the building envelope.

- **Energy-Efficient Construction.**

Using energy-efficient construction techniques reduces the likelihood that warm, moist air will come in contact with cold surfaces, leading to condensation, mold growth, and rot. While building assemblies should be designed to keep moisture—either transported by air or through vapor diffusion—out, they must also allow water vapor to get out if it gets in. There are different strategies to achieve this, and the strategies vary widely depending on the climate. For a good discussion of the approaches, consult a building manual, such as the *EEBA Builder's Guide*, for your climate.

- **Proper Ventilation.** (See the "Active Ventilation" fact sheet for more information.)

Using exhaust fans in the bathrooms and kitchen can remove much of the moisture that builds up from everyday activities. There are exhaust fans on the market that produce little noise, an important consideration for some people. Another benefit to using kitchen and bathroom exhaust fans is that they can reduce levels of organic pollutants that vaporize from hot water used in showers and dishwashers. These fans can be part of an active ventilation system for the entire house and help to reduce humidity levels.

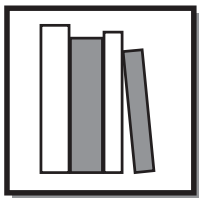
Always vent clothes dryers directly outside. Dryers generate large amounts of moisture. In addition to moisture, dryers also vent particulates, and in the case of gas dryers, combustion products. (See "Active Ventilation" fact sheet for more information.)

- **Size Equipment Correctly.**

Incorrectly sized equipment can lead to operational and cost problems. Oversized air conditioning systems can "short-cycle," leading to rapid cooling without reducing indoor humidity levels. This can lead to a variety of problems associated with high relative humidity. Heat gain and heat loss should be determined for each house. The Air Conditioning Contractors of America (ACCA) provides a recognized standard procedure in the publication, *Manual J*. Equipment should be sized for each individual house because even identically built homes will be affected by variations, such as solar orientation and shading, which affect heating and cooling loads.

- **Ventilation and Relative Humidity.**

By air-sealing and using energy-efficient construction, uncontrolled air leakage is greatly reduced, a more controlled indoor environment is created, and indoor relative humidity is more likely to be maintained at acceptable levels without the use of a humidifier. (Humidifiers require maintenance to avoid becoming breeding grounds for biological contaminants.) If ventilation is included in a tight, energy-efficient house, very low-RH should not be a problem. In fact *high* relative humidity could be a problem in a tight house with no mechanical ventilation.



RESOURCES

- *Moisture Control Handbook : Principles and Practices for Residential and Small Commercial Buildings.* By Joseph Lstiburek, John Carmody. 1991.
- *Builder's Guide - Mixed Climate; Builder's Guide - Cold Climate; Builder's Guide - Hot-Dry & Mixed Dry Climates.* By Joseph Lstiburek. Energy Efficient Building Association & Building Science Corporation. 1998.
- *The Inside Story*. U.S. EPA 402-K-93-007. April 1995.
- *Understand Ventilation*. By John Bower. The Healthy House Institute. 1995.
- *Manual J & Manual D.* The Air-Conditioning Contractors of America (ACCA). 1-202-737-7474.
- *No Regrets Remodeling*. Home Energy Magazine. 1997.
- *Building Foundation Design Handbook*. Kenneth Labs, *et al*. Underground Space Center, University of Minnesota, Minneapolis, MN. 1988.

Improve Indoor Air Quality with
Soil-Gas Reduction Systems

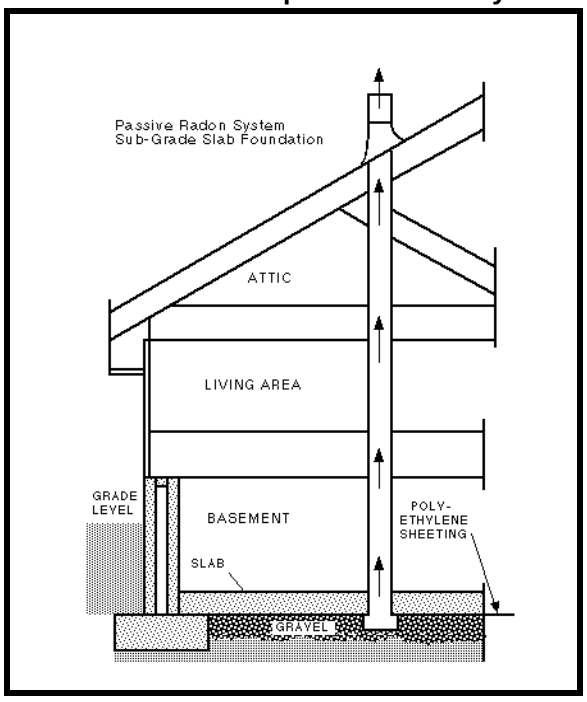
Builder Guide
(in conjunction with the EPA Indoor Environments Division)

DESCRIPTION

There are a variety of soil gases which are of concern for the builder and home buyer. Perhaps the most familiar is water in the form of water vapor which can travel through foundations and crawl space areas. Radon, a radioactive gas which is the second leading cause of lung cancer in the U.S., is another concern in homes. EPA estimates that approximately 14,000 people die each year from radon-related lung cancer. Homes have been found with elevated levels of radon throughout the U.S. People are also concerned about the migration of methane, herbicides, termiticides, and other compounds through the soil.

Fortunately, EPA and the National Association of Home Builders have developed an effective and inexpensive method to reduce the risk from radon and other soil gases. The techniques described in this guide use common building materials and practices, are easy to use in new construction, and can help to reduce soil gas entry into homes.

Passive Sub-Slab Depressurization System



BENEFITS

- Comfortable, healthy homes can increase customer satisfaction by providing a more desirable home. This can close sales and increase referrals.
- Reducing moisture levels below the slab (or in the crawl space) will keep the bottom level of homes drier, decrease the likelihood of mold and mildew growth, and reduce callbacks for these reasons.
- Reduced risk of lung cancer from radon and other health effects from soil gases.

INTEGRATION

- **Passive Sub-slab Depressurization System.**

The passive sub-slab depressurization system (passive system) consists basically of the following techniques:

1. **Gas Permeable Layer:** Usually a 4-inch layer of clean, coarse gravel (no fines) is used beneath the slab to allow the soil gas to move freely beneath the house. Other options are to install a loop of perforated pipe or a soil gas collection mat.
2. **Plastic Sheeting:** 6-mil polyethylene sheeting is placed on top of the gas permeable layer to help prevent the soil gas from entering the home and keep concrete from filling voids in the gas permeable layer when it is poured.
3. **Vent Pipe:** A 3-inch or 4-inch (recommended) PVC or other gas-tight pipe runs from the gas permeable layer to the roof to safely vent radon and other gases above the house, and to slightly depressurize the area below the slab.

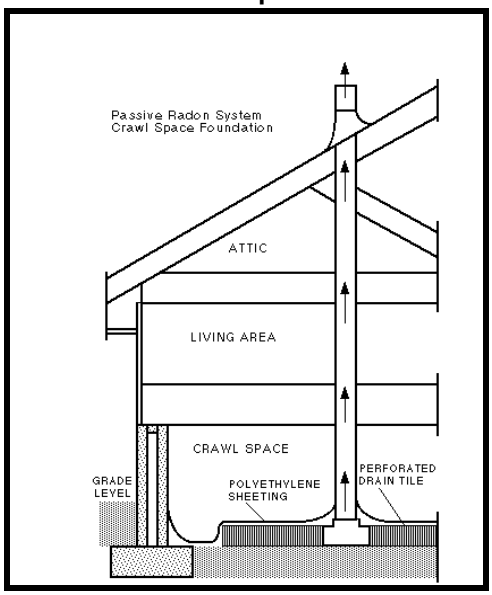
4. **Junction Box:** An electrical junction box is installed in case a venting fan is needed to activate the system. This junction box does not have to be on its own circuit.

5. **Sealing and Caulking:** All joints, cracks, and penetrations in the foundation and slab are sealed to prevent soil gas from entering the home. Air-sealing the rest of the building envelope reduces the stack effect and the tendency for the house to draw gas from the ground.

• Passive System Variations with Crawl Spaces.

The passive system in crawl space is similar to the system described above. The differences are that the plastic membrane covering the entire crawl space floor is sealed to the vent pipe, to any piers, and to the foundation walls. In this system (sometimes called a sub-membrane depressurization system), suction beneath the membrane is enhanced and expanded by connecting the bottom of the vertical vent pipe to sections of perforated vent pipe laid horizontally

Crawl Spaces



under the membrane.

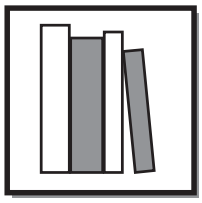
• Test Home For Radon.

While the passive system reduces indoor radon levels by about 50% on average, occasionally the passive system alone will not reduce radon below EPA's *action level* of 4 picoCuries per liter (pCi/L) of air. *The only way to determine the radon level is to test the home after it is built*.

• In-line Fans.

An active system is needed whenever post-construction testing of a passive system reveals an indoor radon reading above 4.0 pCi/L. Some builders install active systems during construction to ensure radon levels are minimized.

The ideal location for a radon suction fan is in the attic where the fan housing and venting pipe can be sheltered from the elements, yet be outside the building's conditioned spaces. In addition, placing the fan in a non-conditioned space prevents the accidental pumping of radon directly into a home's living space should a leak occur in the fan housing or at the vent-pipe joints downstream of the fan.



RESOURCES

- A variety of publications, including a builder kit, builder videos, home buyer educational materials, blueprints, and alternatives and enhancements to the system are available from EPA. Call the IAQ Information Clearinghouse at 1-800-438-4318 or visit EPA's website at www.epa.gov/iaq

- *Builder's Guide - Mixed Climate; Builder's Guide - Cold Climate; Builder's Guide - Hot-Dry & Mixed Dry Climates.* By Joseph Lstiburek. Energy Efficient Building Association & Building Science Corporation. 1998.

- 1995 CABO *One and Two Family Dwelling Code, Appendix F.* 1998 ICC *One and Two Family Dwelling Code, Appendix D.*

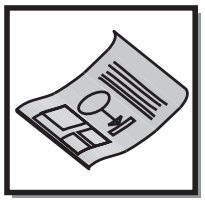
- *Building Radon Resistant Homes: A Builder's Independent Study Kit.* National Association of Home Builders. 1-800-223-2665.

- *Standard Guide for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings* (E 1465-92). ASTM.

Builder Guide
(in conjunction with the EPA Indoor Environments Division)

Improve Indoor Air Quality by

Proper Use of Combustion Equipment

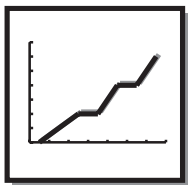


DESCRIPTION

Combustion appliances are those which burn fuels for warmth, cooking, or decorative purposes. Typical fuels are gas, both natural and liquefied petroleum (LP); kerosene; oil; coal; and wood. Examples of appliances are space heaters, ranges, furnaces, fireplaces, water heaters, and clothes dryers. These appliances are usually safe. However, under certain conditions, these appliances can produce combustion pollutants that can damage health, or even kill. In addition, unvented or improperly vented appliances can add large amounts of moisture to the air, potentially resulting in both biological growth and damage to the house.

Proper selection, installation, inspection, and maintenance of combustion appliances are extremely important. Providing good ventilation can also can reduce exposure to combustion pollutants. To maintain good indoor air quality:

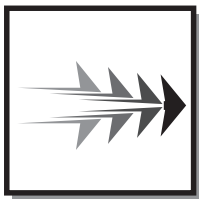
- use proper air balancing;
- ensure that combustion drafts aren't overcome by house pressures;
- consider avoiding unvented appliances and using either sealed combustion or power-vented appliances; and
- properly maintain all appliances.



BENEFITS

- Properly installed and tested appliances are less likely to backdraft or contribute large amounts of moisture to the home. This will reduce liability and callbacks due to complaints of backdrafting of Carbon Monoxide (CO) or other combustion products.

- Comfortable, healthy homes can increase customer satisfaction by providing a more desirable home. This can close sales and increase referrals.



INTEGRATION

- **Avoid Unvented (or "Vent-free") Space or Water Heating Appliances.**

Unvented appliances leave all combustion products in the house. Even if incomplete combustion pollutants such as CO are kept to a minimum, these appliances can generate large amounts of moisture.

- **Consider Using Only Sealed-combustion, Direct-vent, Induced Draft, or Power-vented Furnaces, Boilers, and Water Heaters.**

The risk of backdrafting is lower with these types of equipment than for those relying on natural draft. Natural draft can at times be overcome by conditions that depressurize the house, leading to spillage, backdrafting, and other problems associated with combustion products in the house.

- **Use a Properly Sized Range Hood Fan.**

All kitchens should have exhaust ventilation to remove odors and excess moisture associated with cooking. While there are various ventilation strategies for kitchens, a range hood is the most common. When using a gas range, a range hood directly vented to the outside should be used to capture the combustion products. These range hoods should be sized correctly. For a typical range, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Home Ventilation Institute (HVI) recommend 100 cfm. Larger fans may need to have makeup air provided.

- **On Completion, Test the Combustion Equipment in the House.**

After installation, combustion and ventilation equipment should be tested to be sure that it functions properly. It is also important to conduct a worst-case depressurization test. It is impossible to know the tightness of the house, and how the

ventilation system and combustion appliances interact, without testing. The worst-case test determines if any non-sealed combustion appliances will backdraft or spill combustion products into the living space. Builders should test combustion equipment operation using an established procedure such as Appendix D of the *International Fuel and Gas Code* or ASTM E1998 "Guide for Assessing Backdrafting and Spillage from Vented Combustion Appliances".

- **Use Appliances Properly.**

It is important that home owners understand how to properly operate combustion equipment in their homes. Instructions should include normal inspection and maintenance procedures and schedules. These instructions can be part of a comprehensive "owner's manual" for the home (see the Home Owner's Manual fact sheet).

- **Design Spaces and Install Equipment So that it is Easy to Operate, Inspect, and Maintain.**

Regardless of how well systems equipment is designed and installed, how it functions over time is in large part due to how it is operated and maintained by the occupants. Providing easy access and lighting for the occupant or the occupant's maintenance providers will help enable the owner to run the house properly and should reduce complaints and callbacks.

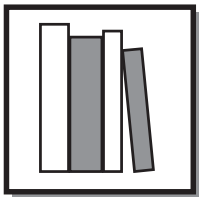
- **Vent Clothes Dryers to the Outside.**

Always vent clothes dryers directly outside. In addition to combustion products produced by gas dryers, all dryers generate large amounts of moisture and particulates which should be vented out of the house before they have the opportunity to create problems.

- **Consider Installing a Carbon Monoxide Alarm.**

Carbon monoxide (CO) is a colorless, odorless gas which at high levels can cause serious illness and death. CO alarms are widely available and should be considered a back-up to—**BUT NOT A REPLACEMENT** for—proper installation, use, and maintenance of fuel-burning appliances. CO alarms are designed to warn occupants of any unusual build-up of CO in a residence. These higher levels of CO may occur from improperly maintained, installed or used fuel-burning appliances, backdrafting appliances or fireplaces, or idling cars in garages. If a CO alarm is to be installed:

a. Make sure the device is certified to the most current Underwriters Laboratory (UL) standard 2034 or the International Approval Services (IAS) 6-96 standard.
b. Install a CO alarm in the hallway near every separate sleeping area.
c. Make sure that the purchaser of the home is aware of all instructions and warnings associated with the CO alarm and knows that this is a back-up—BUT NOT A REPLACEMENT— for proper installation, use, and maintenance of fuel-burning appliances. The CO alarm should not be covered up by furniture or draperies.



RESOURCES

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- *Understand Ventilation*. By John Bower. The Healthy House Institute. 1995.
- *No Regrets Remodeling*. Home Energy Magazine. 1997.
- "Oversized Kitchen Fan—An Exhausting Problem." By Bruce Manclark. *Home Energy*, Vol. 16, No. 1, January/February 1999.
- "What You Show Know About Combustion Appliances and Indoor Air Pollution." Consumer Product Safety Commission, American Lung Association, U.S. EPA.
- ASHRAE Standard 62-1989, "Ventilation for Acceptable Air Quality." American Society of Heating, Refrigerating, and Air-Conditioning Engineers. 1-404-636-8400. www.ashrae.org
- ASTM Standard E1998, "Guide for Assessing Backdrafting and Spillage from Vented Combustion. American Society for Testing and Materials. 100 Barr Harbor Drive, West Conshohocken, PA 19428. Phone: (610) 832-9585 www.astm.org
- U.S. Consumer Product Safety Commission. 1-800-638-CPSC. www.cpsc.gov
- American Gas Association, 1515 Wilson Boulevard, Arlington, VT 22209
- Wood Heating Alliance, 1101 Connecticut N.W., Suite 700, Washington, DC 20036

Improve Indoor Air Quality by Controlling Pollutants

Builder Guide
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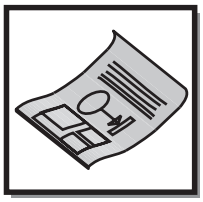
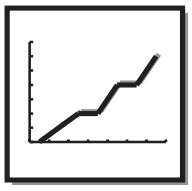


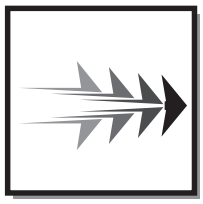
DESCRIPTION

Usually, the most effective way to improve indoor air quality is to eliminate individual sources of pollution or to reduce their emissions. Controlling how pollutants enter and exit the house can also be effective. Some sources, like particle board, can be sealed or enclosed; others, like molds and mildews, can be reduced by proper building design to address moisture control. Radon and other soil gases can be addressed during the construction of a building. Designed control strategies can be used to control sources generated by hobbies or other activities in the home. Another approach to lowering the concentrations of indoor air pollutants is to increase the amount of outdoor air coming into the house. Air cleaners can also be used to improve indoor air quality.



BENEFITS

- Comfortable, healthy homes can increase customer satisfaction by providing a more desirable home. This can close sales and increase referrals.
- Eliminating or reducing pollutant sources can improve indoor air quality and protect occupants' health.
- Construction practices that promote good indoor air quality also help protect the house itself. For example, controlling moisture will prevent mildew odors, premature paint failure, rot, and structural damage, and may reduce callbacks.



INTEGRATION

- **Use Techniques to Reduce Exposure to Radon and Soil-Gases in Homes.**

There are simple ways to reduce radon and other soil gases during home construction. Home owners should be encouraged to test for radon to verify that levels are below EPA's action level. (Refer to "Soil Gas Reduction System" fact sheet for additional information).

- **Reduce Biological Contaminants by Controlling Moisture.**

Some sources of biological contaminants can be minimized by controlling moisture. Strategies to control moisture include using exhaust fans in bathrooms and kitchens, and designing the building envelope to prevent moisture build-up. (See the "Moisture Control" fact sheet for more information.)

- **Ensure Combustion Appliances Are Properly Vented and Receive Enough Supply Air.**

Install space and water heating equipment so that it does not backdraft. Test the equipment under worst-case depressurization of the house to verify that it works properly. If a gas stove is used, install a properly sized range hood that is vented to the outside. Provide information to the homeowner so that all appliances are properly operated and maintained. (Refer to "Proper Use of Combustion Equipment" fact sheet for additional information).

- **Minimize the Use of Building Products Containing Formaldehyde or Other VOCs Within Conditioned Space.**

Pressed wood products, adhesives, and many finishes (such as paints and varnishes) contain volatile organic compounds (VOCs) which off-gas in varying amounts over time. There are several complementary strategies to minimize problems:

- To the extent possible, eliminate or reduce the use of these products inside the living space of the house.
- Consider using solid wood with low-emitting finishes.
- Consider the use of pre-finished materials or those that can be finished outside the living space.
- When engineered products such as pressed wood are used, sealing as many surfaces as possible should help to reduce the rate of emissions. Low-emitting sealants should be used. Check with vendors of engineered wood products for recommendations on sealing their products.
- Use "exterior-grade" pressed wood products (lower-emitting because they contain phenol-formaldehyde resins rather than urea - formaldehyde resins).
- Wherever possible, use low-emitting products in the house's conditioned space, such as sealants, paints, and finishes. Use these products according the manufacturers' directions, and provide plenty of ventilation during and after application. Check with vendors to see whether they have low-emitting products that are suitable for your specific applications.

- **Use Carpets Consistent with Industry Guidelines.**

In recent years, a number of consumers have associated a variety of health symptoms with the installation of new carpet. Despite extensive testing, scientists have not been able to determine whether the chemicals emitted by new carpets are responsible. However, there are prudent steps which you can take to decrease the chance of problems. These include:

- Use carpets with the industry's voluntary emissions labels.
- Try to unroll and air out the carpet in a well-ventilated area before installation.
- Where possible, use carpet tack strips instead of adhesives. Ask for low-emitting adhesives if adhesives are needed.
- Be sure your installer follows the Carpet and Rug Institute's installation guidelines.

- **Avoid Using Carpet in Areas Where it is Susceptible to Excessive Moisture.**

Excessive moisture can lead to mold growth in carpet. Avoid carpet in problem areas around sinks, bathtubs and showers, laundry areas, and entryways which are prone to chronic wetting. Use caution when installing carpet on concrete slabs, as concrete slabs can release significant amounts of moisture during the curing process. Also, in some situations, condensation can form on concrete slabs if the indoor surface temperature of the slab is at or below the dew point of the surrounding air.

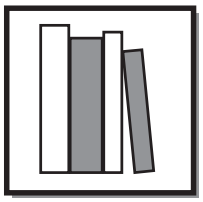
- **Isolate Garages from Living Space.**

Because cars and many home care products and fuels are stored in garages, garages are often sources of pollutants. The more garages can be separated from the living space of a home, the better.

- Consider building detached garages in order to isolate pollutant sources from the living spaces.
- When building attached garages, pay particular attention to air sealing between the living space and garage. This includes the use of airtight doors between the spaces. Also consider how air handling equipment, duct work and exhaust fans within the house may affect the relative pressure difference between the garage and the living space. Try to design and build these systems to maintain a negative pressure in the garage relative to the house, to prevent pollutants from being drawn into the house. Also, install duct work in a manner that prevents garage pollutants from being drawn into return ducts.
- Garages tucked under living spaces can be more difficult to isolate because of the thermal stack effect which could drive the movement of pollutants upwards from the garage into the living space of the house.

- **Design Buildings and Landscaping to Control Pests.**

Houses should be designed so that pets cannot access building components and find building components and cavities inhospitable. Pest include insects, rodents and molds. Important strategies include keeping wood out of contact with the ground, using barriers to prevent insect and rodent access to building cavities, and controlling moisture.



RESOURCES

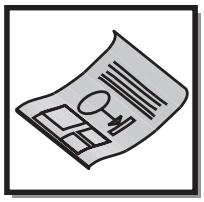
- *The Inside Story*. U.S. EPA 402-K-93-007. April 1995.
- *Builder's Guide - Mixed Climate; Builder's Guide - Cold Climate; Builder's Guide - Hot-Dry & Mixed Dry Climates.* By Joseph Lstiburek. Energy Efficient Building Association & Building Science Corporation. 1998.
- *Moisture Control Handbook : Principles and Practices for Residential and Small Commercial Buildings.* By Joseph Lstiburek, John Carmody.
- *Understanding Ventilation*. By John Bower. The Healthy House Institute. 1995.
- *No Regrets Remodeling*. Home Energy Magazine. 1997.
- *Common Sense Pest Control*. By William Olkowski, et al. The Taunton Press. 1991.

Trade Associations:

- Adhesive and Sealant Council. 1627 K Street, NW, Suite 1000, Washington, DC 20006
- Carpet and Rug Institute. 310 Holiday Avenue, Dalton, GA 30720. (706) 278-3176 www.carpet-rug.com
- Chemical Specialties Manufacturers Association. 1913 I Street, NW, Washington, DC 20006
- Foundation of Wall and Ceiling Industries. 307 East Annandale Road, Suite 200, Falls Church, VA 22042
- National Paint and Coatings Association. 1500 Rhode Island Avenue, NW, Washington, DC 20005

Improve Indoor Air Quality with
A Home Owner's Manual

Builder Guide
(in conjunction with the EPA Indoors Environments Division)



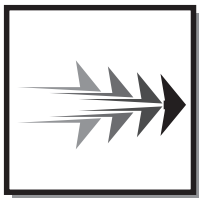
DESCRIPTION

Houses operate as complex systems. The various components of a house—including but not limited to the mechanical systems, plumbing, appliances, and the building shell itself—require proper operation and maintenance on an ongoing basis to function properly and minimize problems. Most homeowners do not understand how all the pieces of a house fit together, nor do they know operation, inspection, and maintenance procedures for all the components. During the course of construction, the builder can compile useful information about the home and prepare and deliver the information to the homeowner.

BENEFITS

- Providing comfortable, healthy homes will increase customer satisfaction and result in a more desirable home. A home owner's manual can help communicate the quality of the home, demonstrate your attention to detail, and show your concern for the long-term value of the home. This will close sales and increase referrals.

- Regardless of how well a home is designed and built, how it functions is in large part due to how it is operated and maintained by the occupants. Giving the occupant the information to run the house properly should reduce complaints and callbacks.



INTEGRATION

- **Compile Information as House is Built.**

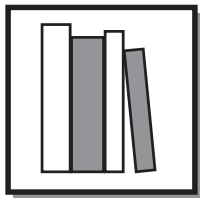
This information should include as-built specifications including a list of materials and products used in the house.

- **Describe Suggested Operating and Maintenance Practices.**

Include in the manual important information about how the house works and what the owner/occupants should do to ensure that it works properly. Included should be:

- General maintenance recommendations
- A discussion of moisture in houses
- Specific operating and maintenance instructions for such things as:
  1. Septic system
  2. Heating, Ventilation, and Air-Conditioning systems, including combustion equipment inspection and servicing, and filter replacement
  3. Fireplace
  4. Appliances
  5. Lighting and lamps
  6. Paints and finishing
  7. Exterior woodwork, sealing, and caulking
  8. Interior woodwork and flooring
  9. Landscape

- **Provide Information About Radon Testing and Passive Soil Gas Reduction System.**



RESOURCES

- "Writing an Owner's Manual for a House." By John Abrams. *Fine Homebuilding*. March 1998.

- *The Inside Story*. U.S. EPA 402-K-93-007. April 1995.

- *Home Buyer's and Seller's Guide to Radon*. U.S. EPA. 402-R-93-003. March 1993.